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Vol. XVII SEPTEMBER, 1929 No. 3

RESEARCH NUMBER

ROSENDAHL ON "LIGHTER-THAN-AIR MACHINES"

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EDITORIAL COMMENTS

We present in this number the reports from the investigators in various fields who held research grants from Sigma Xi during 1928–29. Also we print the report of the Committee on the Awards for the current academic year. They are all interesting reading. Two generalizations are suggested by this presentation: one, the fields of scientific endeavor in which the Sigma Xi investigators are at work are broad, and the second, the fact is gratifying that the Sigma Xi members and associates are maintaining their contacts with the Society in a practical way by supporting financially the purpose of the organization, the promotion of research.

In connection with this branch of the Society's work, the collection and distribution of a research fund, the secretary's office receives many letters, a few of them frankly critical, the great mass of them commending the effort and expressing enthusiastic appreciation and willingness to participate. They come from all over the world. One that reached us in July from Huguenot University College, Wellington, Cape Province, enclosing a draft for $25, is typical. We quote from it.

"Yes, you shall have me with you, if it is not too late. For one of the keenest emotional stimuli I experienced in my college came with the message from my professor that I had been elected to Sigma Xi. ......I should have responded sooner but I am always uncertain whether to make out a draft from my meager African savings or to call upon my sister in America to look behind my chimney brick and sweep the cracks for the amount. Not having your letter with me when I finally decided to send the draft I made it out to Willis R. Whitney, the name I remembered.

"In high school I was reckoned as clever as W. R. W. And now he is calculating protons and electrons, and the amount of power it takes to run a radio twenty-five years in terms of the energy exerted by a fly in an ambulatory excursion of an inch. But I was class poet. To my consternation I learned on my last visit to my alma mater that the species was extinct. Whether I was the last of the species and the extinction is due to maladaptation to conditions, I do not know!

"South Africa has some clever students but no chapter of Sigma Xi. Any surplus in amount would be appreciated for overseas study."

The annual convention of Sigma Xi will be held in Des Moines, December 28. Important business to be transacted will probably include several petitions for charters for chapters at leading institutions. The executive committee will reach final decision as to whether these petitions shall be presented at this time or not at its meeting prior to the convention. Amendments to our national constitution will be offered for consideration, and the resolution offered at the New York convention by the Cornell chapter, the purport of which is to leave with the individual chapters the interpretation of the constitutional definition of membership eligibility, will come up for discussion. The exact wording of this resolution is as follows:

WHEREAS, It is not desirable at this time to attempt to define scientific research in terms of either method or subject matter, *Be It Resolved,* That noteworthy contribution to (or promise of notable accomplishment in) scientific investigation shall constitute eligibility for election to Sigma Xi regardless of the field in which the candidate may be working. Each separate chapter shall be responsible for the interpretation of this principle in election to its membership or associateship.

The sub-committee of the Executive Committee on Convention Programs (Deans Pegram and Ellery) has the honor to announce that the eighth annual Sigma Xi lecture under the joint auspices of the American Association for the Advancement of Science and our Society will be given by Professor G. H. Parker of Harvard University. Professor Parker is a well-known figure in scientific circles and his lecture will be awaited with eagerness and enthusiasm. We cannot, as we go to press, announce his topic but the committee has ventured to suggest that the lecturer deal with some phase of the subject of our animal heritage.

The following amendments to the Constitution will be offered:

I. That Article VI, Section 1, be changed to read as follows:

"On the reverse side or back of the badge shall be engraved the name of the chapter in which the owner was initiated, together with the date of such initiation, and the owner's name."

This proposed amendment omits from the engraving at present required the date of the formation of the chapter.

II. That Article VI, Section 1, be changed to read as follows:

"The badge or symbol to be worn by associates shall be the single letter Sigma in the form of a key. On the reverse side shall be the associate's name, the name of the chapter in which the associate was initiated and the date of the initiation."

This proposed amendment changes the form of associate emblem from a pin to a key.

The president announces the appointment of a nominating committee as follows: Professor Henry B. Ward, Illinois; Professor F. C. Mather, Indiana; Professor E. W. Lindstrom, Iowa State College.

The officers to be chosen by the convention are a president, secretary and treasurer for the ensuing two years; a member of the executive committee for the term of five years, to succeed Dr. Durand, whose term expires in January, 1930; and a member of the Alumni Committee for the ensuing five years, to succeed Mr. C. E. Davies, whose term expires this year.

Recommendations from chapters are requested. They may be made direct to members of the committee, or through the office of the national secretary.

All chapters and clubs are requested to appoint delegates to the convention. At the New York meeting, 31 of our 50 chapters were represented—the largest representation for four years. The national officers request and urge even a better showing at the forthcoming gathering.

DES MOINES, DECEMBER 28, 1929

The secretary has received reports of activities from most of the chapters. Excerpts from these reports will appear in the December issue.

LIGHTER-THAN-AIR MACHINES[1]

By C. E. Rosendahl
Lieutenant Commander, U. S. Navy

Were the designers and promoters of that great distance annihilator, the magic carpet of the Arabian Nights, on hand today, they would no doubt be seriously concerned over the problems of furnishing bigger, better and faster magic carpets, for mankind continues to demand greater speed in transportation. High speed trains and swift steamers with the aid of extra fare continue to flourish; further increases in every-day railroad and steamer speeds are much more expensive and furthermore very difficult to obtain. Fortunately, however, scientific progress has, in comparatively recent years, opened up the most promising transportation medium of all—that by air—and we are now well on the way to enjoy its practical benefits increasingly day by day.

Aircraft are easily classified into two types: the heavier-than-air type represented by the airplane, and the lighter-than-air type represented by the airship. Although the latter term is often used indiscriminately for all types of aircraft, we in the lighter-than-air branch feel that the designation "airship" should properly be applied only to dirigible balloons as they are fundamentally ships that float in air; as a matter of fact, the airship and the submarine are analogous to a large extent both in construction and in operation. The airplane is, of course, an aërodynamic instrument depending entirely on the effort of its engine and propeller to keep it aloft as well as to drive it to its destination. The airship is primarily an aërostatic form of carrier and even though it actually enjoys aërodynamic control over fluctuations of buoyancy and of load, practically the entire effort of its propellers is devoted to its propulsion through the air, and the airship is entirely capable of remaining aloft even should there occur the extremely unlikely failure of all its propulsion plants.

The airplane naturally has the greater appeal to the average individual who wishes to fly his own craft. He pictures himself as the possessor and crew of a plane rather than of a huge airship, just as the average man who wishes to obtain his pleasure on the water gets a

[1] This paper contains material presented at a meeting of the Columbia Chapter. It is reprinted, at the request of the Chapter and by permission of the author from the Proceedings of the American Philosophical Society.

sailboat or a small power-boat and not a sea-going steamer. The airship in the past has not been as well understood as its smaller cousin but the realization is gradually dawning that airships as well as airplanes are essential both to commercial transport and to the national defense. The editor of *The Aëroplane*, a British aëronautical publication, has aptly said: "Airships breed like elephants and airplanes like rabbits. Consequently, the airship is many generations in the process of evolution behind the airplane."

Among the less commonly understood facts in connection with aircraft is the effect on efficiency of increasing the size of such craft. We frequently read of the design and pending construction of "huge airliners" of both lighter-than-air and heavier-than-air types, but actually both types do not lend themselves to the application of the time-worn slogan "bigger and better" as far as efficiency goes. In the case of the airplane, it is known that the limit of efficient increase in size is about to be reached. At a point roughly some two tons heavier than Commander Byrd's plane, the *America*, the larger plane demands a greater proportional amount of "dead" weight and it becomes a less efficient load carrier. We may say with certainty that in the light of present knowledge, the future of the airplane, both in peace and in war, lies in pursuits other than transoceanic transportation and other long-range operations. On the other hand, as we increase the size of an airship, its lifting capacity increases much more rapidly than do its structural and power plant weights. Designers of extensive practical experience have found that the efficiency of rigid airships increases with increased size up to ships of 15,000,000 cubic feet lifting gas capacity, or six times the size of the *Los Angeles*.

It is primarily for these reasons, then, that we maintain that the field of long range aërial transport belongs to the airship. Other reasons, such as the greater facility and ease of navigation and the more abundant comforts of the airships, are also of importance in sustaining this contention. But despite this fundamental difference, there is an abundance of legitimate uses for each type of aircraft and, properly employed, there can be no conflict or competition. The airplane can provide higher speed travel over moderate non-stop distances whereas the airship provides rapid, more comfortable travel, over great distances, and both types are indispensable. A large sea-going steamer might be employed on a short coastal run but that would be an extravagant and inefficient employment; likewise, an airship might inefficiently do some of the functions of an airplane,

but the plane cannot perform the legitimate functions of the airship.

The history of lighter-than-air craft dates back to 1783 when the first balloon flight was made. Men had observed that hot air would rise; therefore by inflating a bag or container of light material with heated air, the container could be made to rise and take with it a basket or car in which to carry passengers or other loads. Soon man was able to produce hydrogen gas in sufficient quantity to inflate a balloon and since hydrogen is so much lighter than air, it has always been the most efficient of lifting gases. In November, 1783 a Frenchman made the first free balloon flight by a human being. The essentials of free-ballooning were all developed in the eighteenth century. But man soon became desirous of providing balloons with motive power so that he might fly independent of the wind. Early effort consisted of rowing in the balloon with silken oars. In 1852 the first power driven or dirigible balloon was built. It derived its motive power from a three-horse-power steam engine and attained a speed of five miles an hour. The modern airship had to wait for the development of the gasoline engine and a light yet strong material with which to build the structure.

Santos Dumont, a rich and romantic young Brazilian with a strong mechanical bent, in the years immediately following 1898 built fourteen airships of various types and did much to arouse interest in flying. Various other efforts along the non-rigid and semi-rigid principles were continued by many others.

It was in 1900 that Count Zeppelin completed and flew his first rigid airship in Germany. In 1908 our first American airship, a small non-rigid type, was built. In 1916 the American Navy began to use small airships and continued until in 1919 their employment in the Navy had dwindled to almost nothing. Later the Navy became interested in rigid airships and constructed the ZR-1, named the *Shenandoah*, in 1923. The ZR-2, contracted for in England, was wrecked and lost there. The ZR-3, later christened the *Los Angeles*, was built in Germany by Allied permission, to replace the two destroyed German Zeppelins which should have been delivered to us. It is thus seen that the United States has operated actually only two rigid airships.

At this point, let me briefly classify lighter-than-air craft. We have: free balloons, which possess no motive power and drift with the wind, the pilot having only up and down control; the captive or kite balloon which floats aloft and is made fast to the earth by a wire cable;

and then come the dirigible balloons which are of three classes—non-rigid, semi-rigid and rigid.

The non-rigid airship is one whose gas bag contains no internal structure and owes its shape solely to the outward pressures of the gas and air contained within it. The semi-rigid has a partial internal structure which it relies upon together with the internal gas and air pressures to maintain its shape. The rigid airship is one whose form is maintained entirely by a rigid skeleton structure. There are a number of non-rigids in this country—our Navy now operates the J-3 and the J-4 for training purposes and our Army has several similar ships called the TC class. Non-rigid airships are of necessity small but can cruise at 55 or more miles per hour for between 12 and 24 hours. They are useful for convoy work, coastal patrol, anti-submarine work, photography and mapping and a number of other purposes.

Semi-rigid airships have a somewhat greater range and greater carrying capacity than the non-rigid and form the intermediate step to the rigid airship. The Navy has no semi-rigids at the present time but the Army operates one, the RS-1, from Scott Field, Illinois. The Russians, Japanese and Italians favor the semi-rigid and it was a ship of this type, the *Norge*, which carried the Amundsen-Ellsworth-Nobile Expedition over the North Pole in 1926. The rigid airship, of which the *Los Angeles* is an example, has a much greater cruising radius and carrying ability than the other two classes. It is the rigid type that we consider holds such high potentialities for aërial transportation.

In order that you may better understand the usefulness of the rigid airship, let me point out a few of its outstanding flights:

(*a*) Small commercial rigid airships operated in Germany both before and after the war and carried 37,000 passengers without accident or mishap. Most of this was before the war, as the post-war commercial ships had to be delivered to the Allies after only brief German operation. The proof of this commercial venture was that the ships practically always carried capacity loads. The Bodensee, one of these commercial airships, was turned over to the Italians and is still operated by the Italian air force today.

(*b*) The German L-59, in November, 1917, took off from her base in Bulgaria, carrying a cargo of fourteen tons of medical supplies and small arms ammunition to the besieged German East African Colonies. Just as the destination was about reached, a radio

message was received by the airship stating that the German Colony had surrendered. She therefore returned to her base without landing. Although she had been in the air for almost 100 hours and had traveled about 4500 miles with her fourteen-ton cargo, upon landing she still had sufficient fuel for an additional 48 hours' flight.

(*c*) The round trip of the British R-34 between England and the United States in July, 1919, was a noteworthy achievement, as that type and size vessel was then already obsolete.

(*d*) In October, 1924, our American built *Shenandoah*, modeled after the German 1916 war type but not completed until 1923, cruised across the continent, up the Pacific Coast and returned to Lakehurst, having covered over 9000 miles in many kinds of weather, basing entirely on mooring masts for over 19 days.

(*e*) The Zeppelin *Dixmude*, while operated by the French, stayed aloft for 118 hours or nearly five days, making the world's record for aircraft.

(*f*) The *Los Angeles*, then designated as the ZR-3, on her delivery flight from Germany in October, 1924, covered 5060 miles in eighty-one hours, spanning the actual ocean expanse in sixty-one hours, her average speed being over 62 miles per hour. This more modern ship thus showed a much better performance than the earlier R-34.

(*g*) Time does not permit recounting to you here the varied war-time uses to which airships were put, but they were many and important.

(*h*) It is significant to note that until the recent crossing by the Junkers plane *Bremen*, the only successful westbound flights across the Atlantic have been made by airships and the first of these as far back as 1919.

All these flights were made with ships that do not compare in size or otherwise with the airships we shall soon see in operation.

And here are some of the recent developments in the airship situation. In England nearing completion are two huge commercial airships of 5,000,000 cubic feet capacity—each twice as large as the *Los Angeles*, and each capable of carrying one hundred passengers in comfort for 4000 miles. Commander Burney is in the United States today arranging for a probable visit of the first of these two ships to the United States this fall. The second of these ships will be finished only a little later. Great Britain has built these two large airships to unite her Empire more closely and accordingly has laid out an airship route from England to India via Egypt; servicing

stations and terminal facilities are nearly complete and mooring masts are to be built in Canada as well. By airship from England to Canada will take two and one-half days, whereas steamers now require six days; from England to Egypt will require two and one-half days by airship as opposed to six days by steamer; from England to Singapore will require eight days by airship whereas twenty-four days are required by steamer—making a possible saving of sixteen days by airship.

At this very moment in Friedrichshafen, Germany, the birthplace of the *Los Angeles*, the airship LZ-127 (to be called the *Count Zeppelin*) is being rushed to completion and her maiden voyages across the Atlantic to the United States are expected to be made this early fall. This ship, one and one-half times the size of the *Los Angeles*, built largely by popular subscriptions by the German people, embodies a number of novel features. This ship was intended to be operated under a subsidy from the Spanish Government for a commercial run between Spain and the Argentine. Unfortunately, recent despatches indicate that the Argentine terminal will not be ready at the scheduled time so that the LZ-127 may not be enabled to undertake the South American run, but there are many other fields open to her.

And what about new construction in the United States? At present our only large airship is the *Los Angeles*. The last Congress authorized as a part of the five-year aircraft building program, two large naval rigid airships of about six million cubic feet gas capacity—larger than even the new British ships about to be completed. Unfortunately their construction has not yet been begun—we hope and expect it will be in the immediate future. These ships will embody a number of novel features of great importance.

It is easy to realize the commercial possibilities of aircraft and particularly of airships. In order to present clearly and briefly what the *Naval* functions of airships are, I can do no better than to quote from a Congressional report which was rendered only last year. After an exhaustive investigation the report rendered reads partly as follows:

"The Committee finds that airships of adequate size hold unquestionable possibilities as adjuncts to the Fleet. Large airships are peculiarly naval as their sphere of greatest usefulness lies over the water; they are essentially long-distance, weight-carrying machines, having long radii of action, ability to keep in the air for long

periods, superior habitability, the ability to operate at night successfully without the necessity for elaborate lighted airways, and wide range of speed variation to the extent of being able to stop all engines and still remain aloft.

"Their principal naval mission will be scouting and reconnaissance augmented by such uses as anti-submarine operations, convoy work, carrying airplanes, transportation of and communication with detached units and, under certain conditions, bombing.

"In the case of a large airship of proved type of construction, built so that interior parts are accessible for repair during flight; filled with non-inflammable helium gas; equipped with machine guns for defense or limited offense; and carrying two or more airplanes for self-protection, vulnerability will be reduced to a point where it will not militate against the airship playing an influential rôle in military operations.

"So decided are the possibilities of lighter-than-air craft, it is felt that we cannot afford to do otherwise than to follow up its present advantage and determine the utility and limitations of rigid airships when employed in active operations with our other naval forces; we have all the necessary facilities and are prepared to go ahead vigorously with the further development of this type of craft. The Committee has found that rigid airship development in this country lags far behind airplane development. The expenditures on airships have been only about 2 per cent of the total expenditures for aviation. It is believed that the construction of the two rigid airships included in the bill will go far toward building up in this country an airship industry, which, when it is established on a sound basis, will be in a position to carry forward the commercial development of airships.

"The Committee feels that the least that should be done in this field is to provide for two rigid airships of approximately 6,000,000 cubic feet volume each, to be used as adjuncts to the fleet." This ends the quotation.

It is interesting to note that the German naval commanders, on at least several occasions, postponed movements of their naval forces awaiting the availability of their airship scouting forces. British wartime naval commanders saw the benefits of airship scouts but although a large airship construction program was begun, British rigid airships could not be finished in time for their use in the World War. Whatever may be the actual relative value of modern surface scouts

and of modern airships remains to be determined, but it is certain that each, and particularly the airship, has improved and any well rounded Navy requires both types.

By joint agreement with the Army and to prevent duplication, our Navy is charged with the development of rigid airships in the United States. While airships do hold great potentialities, we who work with them know also that airships are not yet wholly perfected instruments. The problems of both military and commercial airships have so far coincided to a large extent. As our contribution to airship progress, we have conducted many experiments that are about to produce their results within the near future. The greatest problems of airship operation in the past have been those due to inherited undeveloped methods and equipment for handling airships on the ground—in other words, terminal facilities for airships have been inefficient and inadequate. It is remarkable indeed that airships, handled only by man power on the ground, have been able to do as much as they have. However, we are never content to do with man power what we can develop mechanical power to do and this substitution of machines for most of the men now used on the ground is the major problem we in the United States hope to have solved in the near future. We hope eventually to make the airship just as available as steamers now are; the airship will not have to be berthed in a shed regularly but will moor outside between flights and go into a hanger only for "dry-docking." I do not imagine that the pioneers in the early development of railroads and steamships could possibly have visualized the vast extent and scope of the auxiliaries that remained to be developed to make their new means of transportation sufficiently flexible. I do not believe they even dreamed of the vast amount of dredging, tunneling, elaborate docks, fleets of tugs, drydocks, etc., that were found to be necessary. Similarly in the pioneering stage of aircraft, analogous facilities are just being developed and some of the problems involved are quite complicated. Seaports grew up where nature had already provided certain natural features such as deep and broad expanses of water. Man would not attempt to make a seaport along a shelving sandy beach nor would he expect to use for that purpose a location where tides of sixty feet prevail. Yet we attempt to put airports anywhere and everywhere and it is only recently that the realization is becoming more general that, for airships at least, some geographical locations are very much better endowed fundamentally by nature as airport sites than are others. However, in his

wildest dreams no enthusiast has ever proposed for airships such an expensive auxiliary as that of numerous artificial islands in the sea—airships do not require them. Aircraft may always be dependent to some extent—a continuously decreasing one fortunately—on weather but this is no reason for abandoning flying. Even stolid surface craft after hundreds of years of development are not immune to the caprices of the weather. There will, of course, always be hazards in flying—there still are in railroads, automobiles and steamers, but their use goes on.

In the matter of comforts in travel, airships can provide the best. In modern airships you ride in a sheltered structure, there is no noise, vibration, dirt, smoke, and the motion, when there is any, is usually only a very mild gradual pitching. I have never seen any seasickness in an airship. There are ample comforts for sitting, sleeping, reading, writing, card playing, walking about and exercising and the new passenger airships contemplate even ballrooms. But, of most importance, the airship provides an electric kitchen which can furnish as satisfactory a menu as can be desired. Perhaps airships will never provide swimming pools as huge steamers do, but when you are crossing the Atlantic in two days instead of six you can probably dispense with your daily swim for that period. Fogs, muddy or snow covered fields present no insurmountable difficulties for airships, and airship flight at night and in darkness is generally even easier than in the daytime. It is in the field of transoceanic rather than in transcontinental transport that the airship will soon be a competitor.

Airships are capable of many improvements as they become larger—"bigger and better" is a correct slogan for airships up to at least six times the size of the *Los Angeles*. And what is more important, as earlier indicated, the efficiency of the airship or the amount of its useful load compared to its "dead" load increases with larger ships. With this increase it becomes possible to add structural strength, more speed and greater performance—all factors of great importance. All this is possible in the light of present principles of design and construction and with the materials now available; the future may and probably does hold new variations in construction and design and also lighter materials which will add to increased airship efficiency.

In passing let us take a brief glance at some of the greater airship problems that have confronted us in the United States.

First of all, there has been a lack of airships with which to carry on. At no time have we ever had more than one rigid airship in operating

condition. With numerous projects demanding attention, their trial has necessarily been slow. We have not been able to benefit by simultaneous and competitive trials of experimental installations such as has been practicable in airplane and surface ship endeavors because of their greater numbers. It must be borne in mind also that our actual rigid airship operating experience did not begin until late in 1923 and was unavoidably subjected to numerous interruptions in flying.

The lack of airship bases has handicapped development of airships in this country. There is only one base in the United States—Lakehurst—properly fully fitted for handling rigid airships. A few secondary bases such as are afforded by high mooring masts are widely scattered but these are not wholly perfect nor all that we could desire. Consequently most flights have had to be planned to begin at Lakehurst and to finish there. Of course it is true that we now, through actual experience, know better what requirements should be fulfilled at operating bases, and any airship ports to be built in the future will prove more efficient and even less expensive than those of the past. Where training and experimental flights are of primary importance, the selection of the site for an airship base must receive serious consideration. We do not learn to swim by being thrown overboard in a rough sea and, in the past, operations have been materially influenced largely by the unfavorable meteorological location of our one airship base.

Undeveloped handling methods have already been pointed out as one of the most urgent airship operating problems demanding solution. It must be borne in mind also, that in the compromise between weight and strength, all rigid airships at present in existence, as well as those of the past, were designed and constructed with flying qualities and considerations predominant, whereas handling was left a secondary matter. We are certain that future design can and must yield more to handling considerations.

The present tall mooring mast has served as an important link in the transition period of airships; but, unfortunately, it has limitations. The most serious drawback to the high mast is the danger to the moored ship from vertical air currents. The common conception of wind is that of a mere horizontal flow of air and were this idea always true, flying would be comparatively simple. It so happens, however, that the atmosphere abounds in waves and in vertical currents of air as well as in the common horizontal flow. Squalls and

thunderstorms we know are accompanied by vertical currents and, although airships have ridden out storms while moored to a mast, it becomes a matter of serious consideration when one thinks of what might be the result in extreme cases when the ship, riding normally at a high mast with only her nose secured, has the stern lifted violently upward or perhaps forced violently downward together with rapid change in azimuth. Lightning and precipitation are not so much to be feared. It is my opinion that the proper place for mooring out a ship is at or very near the ground in the currents of lower velocity, where the nose may be held in an arrangement which will give perfect freedom to answer the wind and where the stern may be controlled vertically, yet given freedom horizontally to travel over the ground. But before this idea can be executed, it has been necessary to obtain a great deal of data on the strength and directional variations of gusts in order to determine whether the loads imposed would be within the safe limitations of the ship's structure. This meteorological data was not already available and required specially designed instruments for obtaining it. Although the structure and other characteristics of gusts have not yet been accurately analyzed, there is sufficiently great promise already indicated to warrant proceeding with the application of this mooring scheme.

I believe that when landing, mooring out and handling problems are correctly solved and the large ground crews accordingly reduced, the moment will have arrived when commercial enterprise can safely step into the operation of rigid airships. There will always be other features that require development and refinement, but they are of such a nature that I believe their overhead can be readily absorbed. During the immediate future there will be demonstrated at Lakehurst the use of equipment, largely mechanical, which is the result of our experience. It is believed that this equipment, when refined, will prove the basis for the successful solution of terminal problems.

The helium situation has not always been satisfactory in the past. On several occasions our reserve operating supply of helium has dwindled to nothing and, coupled with certain other avoidable material conditions, has at times forced our airships out of operation. Born under war time conditions and necessarily of a pioneering nature, our original helium project proved of entirely insufficient scope for even our peace time needs; not because of any major difficulties but rather because of actually small ones easily capable of remedy.

The United States is committed to a helium inflation policy and it is interesting to note the high regard of other nations for this safer buoyant medium.

The last Congress provided an appropriation of $1,063,000 for expansion and development of the helium project. The results of this are yet in the future but it will allow continuation of the work necessary to produce cheap helium. Also, recently private capital entered the field of helium production and the real issue of producing helium cheaply should very soon be achieved. Private enterprise in the helium field is certainly necessary before commercial operation of airships becomes feasible. Present indications point to an abundant supply of helium for generations for all the airships we shall probably operate.

Heretofore, man's ordinary routine of life has found two daily weather maps sufficient. For years, the Weather Bureau, twice daily, has collected meteorological readings from a large number of stations scattered over the United States and certain possessions, and parts of Canada. Utilizing these readings, synoptic charts are constructed from which the forecasts are made. With the means and funds available, the Weather Bureau has done wonders, but the speeding up of life by the present and promised prevalence of flying and aërial transportation makes the present weather service inadequate, at least for flying needs.

In flying, one changes his location so rapidly that he may be continuously running into new weather conditions, and aircraft in flight thus require frequent weather data. Not only is it necessary to have knowledge of dangerous weather conditions so that they may be avoided, but it is equally important to be able to take the maximum advantage of favorable and beneficial conditions.

To make transoceanic flying common and safe, as it will be in a few years, we must duplicate for the ocean expanse what we have been doing in the way of weather information for terra firma. For special flights, the Weather Bureau has obtained readings from the numerous ships at sea and drawn the necessary maps. However, although this service would be, even under ordinary conditions, of inestimable value even for surface craft, lack of funds has made it impossible to render this great public aid. Some day we shall come to the realization of this world weather service as a means toward securing greater friendliness and coöperation among nations as well as being of greater benefit to the air and surface sailors of all nations.

With the coming, in a few months, of transoceanic airships, this service becomes mandatory.

There are other interesting problems also but perhaps you may be interested in visualizing a few of the new features of our new airships. As I have indicated earlier, the larger the airship, the greater is the proportion of useful lift provided. We may expend this increase by providing stronger ships, greater speed and greater performance. Actually we intend to gain in all three of these lines. Instead of long slender ships of the *Shenandoah* design, the tendency is to the comparatively shorter and fatter type. Instead of only one longitudinal corridor as in ships of the past, there will be 3 or 4 such passageways in our new ships, thereby providing much greater longitudinal strength. The *Shenandoah* and all rigids up to this time of course had only one such corridor. In our ships inflated with the safe helium gas, we shall put all the engines inside the hull and thereby eliminate the present high resistance of external power cars. Provision will also be made for obtaining thrust from the propellers not only ahead and astern but also up and down vertically—a great advantage for landing and taking off. And perhaps a little more startling, our new naval ships will each have an interior stowage for four service type airplanes and a means of attaching them and detaching them in flight. Commercial airships also will find this airplane adjunct of indispensable value.

The building of the two new naval rigid airships in this country should be the first and most important step in the establishment of an American airship industry. We are now behind Europe in airship construction and will be for several years. The National Advisory Committee last year had to report briefly: "The World leadership in the design and construction of rigid airships has passed from the United States to Europe." This situation need be only a temporary one—our fortunate monopoly of the supply of the entire safe helium gas, although not as well appreciated as it possibly should be, alone gives us a world wide advantage in safety for airships. Other problems are equally capable of solution.

We can regain our supremacy in airships by going ahead at once with new ships of modern size and characteristics. The *Los Angeles*, now hailed as a "giant airship," will very soon be considered a small ship. It is my opinion that huge airships as well as airplanes will prove to be of indispensable commercial value and an auxiliary of high naval value that will add strength to our American Navy and

the American nation. But, what is more, by providing intimate and rapid contact of the peoples of the earth, the airship will soon be recognized as an instrument of the highest order for helping reach that elusive goal of world peace.

LIST OF MISSING PERSONS

Can You Help Us Locate These Members?

Name	*Chapter*	*Last Known Address*
Barnett, Israel Albert	Chicago 1916	Univ. of Saskatchewan, Saskatoon, Sask., Canada
Barnett, Stewart Charles	Penn. 1916	5843 Belmar Terrace, Philadelphia, Pa.
Barney, Jesse Edmond	Cornell 1899	Perrine, Florida
Barrows, Mrs. D. R.	Colo.-Idaho 1922	Redlands, California
Barss, William Raymond	Yale 1909	25 Milton St., Arlington, Mass.
Barthalemew, Dr. Howard B.	Yale 1912	Cobleskill, New York
Bartholomew, Robert P.	Wis. 1916	
Bartlett, Fred William	Mich. 1921	University of Michigan, Ann Arbor, Mich.
Barton, Donald Clinton	Washington 1916	Empire Gas & Fuel Co., Bartlesville, Okla.
Bartsch, Paul	Iowa 1905 D. C. 1915	Government Medical School, Washington, D. C.
Barus, Maxwell	Brown 1910	
Bassett, Charles F.	Illinois 1923	Castile, New York
Bassett, James Wellington	Cornell 1920	761 McMakin Ave., Cincinnati, Ohio
Bassow, Solomon	Colorado 1922	
Baster, Forest Scott	Case 1918	2509 East 22nd St., Langdon, D. C.
Bastron, Dr. C. H.	Nebraska 1916	527 Sec. Mutual Life Bldg., Lincoln, Nebraska
Batch, Richard Marvin	Ohio 1921	Y. M. C. A., Kansas City, Missouri
Bate, Francesca	Northwestern 1922	328 Dempster St., Evanston, Ill.
Bates, Albert Henry	Minn. 1905	Emerson Brantingham Co., 2723 University Ave. S. E., Minneapolis, Minn.
Batesole, Dwight E.	Ohio 1916	208 S. LaSalle St., Chicago, Ill.
Batley, Edward A.	Cornell 1915	Van Zandt & Jacobs Collar Co., Troy, New York
Batson, Oscar, C. V. (Prof.)	Wis. 1921 Cincinnati 1926	Harvard University, Cambridge, Mass.
Battin, Isaac L.	Swarthmore 1924	
Bauer, S. A.	Case 1920	Bolton Pratt Construction Co., Cleveland, Ohio
Bauer, Virginia Lew	Chicago 1921	University of Chicago, Chicago, Ill.
Baum, Anna Elizabeth	Iowa 1913	1417 Concert St., Keokuk, Iowa
Baum, Edwin Kenneth	Stanford 1923	1047 "O" St., Fresno, Calif.

Baum, Harry L. (Prof.)	Colorado 1926	Univ. of Colo. Medical School, 4200 East 9th St., Denver, Colorado
Bausman, Clarence C.	Minnesota 1918	1110 Lincoln Way, Ames, Iowa
Baumann, Louis	Iowa 1916	
Baxter, Burke Morgan	Case 1906; Penn. 1906	
Baxter, G. Winnifred	Syracuse 1916	Griffin, Florida
Baxter, Mrs. James (Anna Strang)	Wis. 1917	15 Kilbourn Road, Belmont, Mass.
Beach, Harry Lee	Worcester 1923	Bristol, Conn.
Beach, Walter R.	Case 1921	14 Dundern Place, Winnipeg, Manitoba, Canada
Beam, Mark P.	Colorado 1923	4200 East 9th St., Denver, Colorado
Bean, Arthur N.	Iowa 1906	
Beattie, Ruth	Washington 1917	
Beaven, Dr. Paul Webley	Michigan 1919	University of Michigan, Ann Arbor, Mich.
Bechdel, S. I.	Minnesota 1926	
Becht, Frank Christian	Chicago 1907 Ill. 1910	5419 Greenwood Ave., Chicago, Ill.
Beck, Elfred	Nebraska 1920	2905 Montana Ave., Billings, Montana
Becker, Albert J. (Prof.)	Ill. 1915	Univ. of North Dakota, Grand Forks, N. D.
Becker, George	Minn. 1897	
Becker, Lewis Michael	Colorado 1917	Dept. Mechanical Engr. Univ. of Colorado, Boulder, Colo.
Becker, R. B.	Minnesota 1926	
Bedell, Harold Leslie	Neb. 1924	Davenport, Neb.
Beeber, John	Ames (Iowa State College)	
Beeson, Joseph	Stanford 1915	Judge Bldg., Salt Lake City, Utah
Beghtel, Floyd Eldon	Ind. 1917 (Cincinnati 1926)	
Behneman, Harold M. F.	Wis. 1923	Washington University, St. Louis, Missouri
Behre, Henry August	Yale 1915	57 Mackay St., Port Washington, N. Y.
Beifeld, Albert Henry (Prof.)	Mich. 1915	Univ. of Michigan, Ann Arbor, Mich.
Beinecke, Fritz W.	Yale 1909	1015 Broad St., Newark, N. J.
Bell, D. T.	Cincinnati 1928	University of Cincinnati, Cincinnati, Ohio
Bell, Herbert	Chicago 1919	University of Chicago, Chicago, Ill.
Bell, James Clark	Rens. 1906	Rochester, N. Y.
Bell, Rodney Linton	Ill. 1909	Paris, Illinois
Bellamy, Albert William	Chicago 1917	University of Chicago, Chicago, Ill.
Bencowitz, Isaac	Columbia 1923	1160 Eastern Parkway Brooklyn, N. Y.

REPORTS OF INVESTIGATIONS MADE ON SIGMA XI GRANTS, 1928-29

MISS JOYCE HEDRICK, MIAMI UNIVERSITY

Miss Hedrick is completing the work of Dr. Bruce Fink on "Lichen Flora of the United States" which was so unfortunately interrupted by Dr. Fink's sudden death in 1927. During 1928–29 part of the Sigma Xi grant was used for typing corrected descriptions. With the remainder, work on describing and determining was carried on. 65 specific descriptions were completed, and between 75 and 100 United States lichens were determined, from Texas, Oklahoma, Illinois and Tennessee.

PHOTOCHEMICAL POLYMERIZATION OF STYRENE

ARTHUR A. VERNON, PRINCETON UNIVERSITY

Aside from the observations that various organic compounds polymerize under the influence of heat and of light, no quantitative measurements have been made upon the course of such reactions, nor on the factors influencing them. Stobbe and Pospiak[1] have made some measurements on the molecular weight of styrene and other compounds polymerized under the influence of ultra-violet light and Standinger[2] has shown that, for several compounds, viscosity depends upon molecular weight. Moureau and Dufraisse[3] have also determined that the oxidation of acrolein is accompanied by a polymerization and another investigator[4] has determined that a similar condition is true for the oxidation of styrene.

In view of this situation, it was felt that a quantitative study of the polymerization of styrene under the influence of light would be instructive with regard to both the polymerization process and the chain reaction interpretation of many chemical reactions.

The experimental method consisted in illuminating a solution of styrene in ethyl benzene with a mercury arc, following the progress of the reaction by measuring the viscosity change and also the

[1] *Ann.*, 371, 259 (1909).
[2] *Ber.*, 59, 3031 (1920).
[3] *Bulletin de la Société Chimique de France*, 9th t. 35.
[4] Milas, *Proc. Roy. Soc.*

change in depression of freezing point of a benzene solution. The solution was from thirty to fifty per cent styrene and was used both because such a mixture could be obtained more cheaply than pure styrene and also because viscosity measurements could be spread out over a larger range of operating conditions than would have been possible with styrene alone. It was soon found that the curve of viscosity change plotted against time of illumination would not give an indication of amount polymerized but could only be used in the interpretation of the size of aggregate molecules. To obtain a quantitative measure of the amount polymerized, one cubic centimeter of the reaction mixture was dissolved before illumination in twenty-five cubic centimeters of benzene and the depression of the freezing point of pure benzene determined. After illumination, the same thing was done and the resultant change in depression of the freezing point of benzene gave an exact measure of the amount of styrene which had been polymerized. This was true since the size of the molecules of polymer was such that their effect upon the freezing point of benzene could be neglected in comparison with that of the unpolymerized styrene and the ethyl benzene. To avoid all effects of oxygen, the solution, before illumination, was steam distilled in hydrogen and the polymerization effected in the presence of hydrogen by employing reaction vessels with ground glass joints so that all the air would be flushed out. The vessels were made of pyrex tubing about one inch in diameter and six inches long. Four of these vessels were immersed in a cylindrical copper water bath eight inches in diameter, in the center of which was fastened a piece of quartz tubing in a water-tight seal. The mercury arc was supported in this quartz tubing and ran at about 180 watts. By means of this arrangement, the temperature of the reaction solution could be controlled and four duplicates of each experiment could be made.

RESULTS

The first point to be settled was that concerning the reproducibility of the experiments and whether the effects of oxygen had been eliminated. Experiments were made with steam-distilled solutions which had been divided into two parts. One part was sealed in a bottle over hydrogen and the other part over oxygen. Samples were tested at various intervals by illumination at 100° C. for the same length of time.

The results of these experiments are shown in the following table which shows the per cent polymerized per hour after various time intervals.

TABLE I

Time of Standing, Hrs.	Stored over Hydrogen, Per cent	Stored over Oxygen, Per cent
0	6.39	6.39
48	6.50	9.14
96	6.20	9.15
144	5.85	10.25

This shows very markedly the effect of acceleration of polymerization due to absorbed oxygen and also the constancy of results obtained when the reaction mixture was stored over hydrogen. In all succeeding experiments values within 10 per cent of those indicated above for hydrogen were obtained and in no case did the solution stand over 24 hours—always in contact with hydrogen.

A further check was made on the condition of experiment by making a test on some solution which had been distilled in vacuum after having been previously steam distilled in oxygen-free hydrogen. This test gave a rate of polymerization of 5.2 per cent per hour. While this is in poorer agreement with the average of the hydrogen distilled tests than the hydrogen distilled tests are among themselves, there is one point to be taken into consideration. As a result of the distillation in vacuum, the concentration of styrene in this solution was less than normal due to the different vapor pressures of styrene and ethyl benzene. Subsequent experiments have shown that the rate depends upon the concentration and hence, taking this into consideration, the vacuum rate is in good agreement with the hydrogen-distilled rate. The conclusion seems valid, therefore, that the effects of oxygen have been eliminated and that the method gives results which are those due to photochemical polymerization alone with the effects of oxygen eliminated.

Using the method outlined above, the further details of the polymerization process were determined. Photochemical polymerizations were carried out at 30° C., 70° C. and 100° C. Measurements made at frequent intervals in the course of a run indicated the rate of polymerization. The depression of the benzene solution plotted against time gave a straight line relation for each temperature. The rates at 70° C. and 100° C. were corrected for thermal polymerization and from the resultant curves the temperature coefficients of the reaction were calculated.

TABLE II

Temp. Coefficient between 30° and 100° C.	1.306/10° rise
Temp. Coefficient between 30° and 70° C.	1.331/10° rise
Temp. Coefficient between 70° and 100° C.	1.272/10° rise

The next point determined was the effect of inhibitors upon the reaction. Hydroquinone was used and the average of many tests is embodied in the table below.

TABLE III

Concentration of Hydroquinone	Polymerization Rate of Normal, Per cent
1 part of 160	0
1 part in 400	24
1 part in 800	49.1
1 part in 4000	86

These results show a proportionality to concentration which is in very good agreement with a direct relationship especially when consideration is taken of the fact that the errors at low and high concentrations are very great due to the inability to detect a 3 or 4 per cent change. For the present, we can say that this effect is due to deactivation of the initially or secondarily activated molecules and that it indicates a velocity equation of the type-velocity = $\frac{K_1}{K_2 + C}$ where C is the concentration of the inhibitor and the K_2 is necessary since the velocity is finite when C is zero.

Another influence which was investigated quite extensively was that of the effect of concentration of styrene in the solution upon the rate of polymerization. Several solutions were made of different concentrations and illuminated for four hours. The results are given below.

TABLE IV

Concentration of Styrene, Per cent	Changes in Viscosity, Units	Change in Depression of Freezing Point, ° C.
10	50	0.030
30	84	0.160
65	150	0.20
100	149	0.305

These results show very strikingly the fact that the number of activated styrene molecules which react is much greater at high concentrations than at low concentrations. This is interpreted from the fact that the freezing point change is ten-fold greater at high

than at low concentrations while the viscosity only changes by a factor of three. The increase in viscosity cannot mean a very great lengthening of the chains and hence increase in size of polymer since in that case the viscosity change should be much greater.

A final test of whether such an interpretation is valid or not will depend upon quantum yield measurements made with monochromatic light of different wave-lengths. Some preliminary measurements indicate this to be the case as the quantum yield for the line 2536 Å has been found to be at least three times that at 3130 Å. It is hoped that more accurate measurements may be made in the future upon these two lines and also the 1849 Å line. With these data a full interpretation of the polymerization process should be possible and light thrown on a reaction which heretofore has merely been known to take place.

To make the study of polymerization processes complete, it was felt that some other compound should also be investigated. With this end in view, a study of the polymerization of vinyl acetate was undertaken. This compound has an unsaturated bond as has styrene but differs from it in that oxygen is present in the molecule and the benzene ring is absent. Much trouble was experienced in obtaining reproducible results until it was found that oxygen inhibited the polymerization. A solution of vinyl acetate in ethyl acetate was used and by causing the photochemical polymerization to take place in the presence of hydrogen, a method exactly the same as described above gave reproducible results. It is hoped in the future to investigate fully the influence of the same factors upon this polymerization as was done for the case of styrene in ethyl benzene. When this is done, a fairly complete and quantitative survey of some polymerization processes will have been made.

MISS A. ELIZABETH ADAMS, MOUNT HOLYOKE COLLEGE:

"I have been working on the problem of the effects of pneumectomy in Triturus and a considerable amount of time has been used in the operations and the money has been expended in the following ways:

For technical assistance: In caring for the operated animals and their controls.

In preparation of material for histological study of operated animals and controls, such as blood smears, blood counts, in-

jections of the circulatory system, sections of hearts, sections of skin, etc.

Since it is, of course, necessary to allow the operated animals to live for some time before hoping to secure results, either positive or negative, the work is still in its beginning stages but it is in progress. So far I have not spent all of the money but expect to use the remainder in completing the work which has been started."

CARL R. A. SCHMIDT, UNIVERSITY OF CALIFORNIA:

"Chapman, Greenberg and Schmidt, in attempting to elucidate the phenomenon of dyeing and staining, studied the reaction which takes place between certain acid dyes and proteins. Their data indicate that the combination between the proteins and dyes studied takes place in stoichiometric proportions.

"With the coöperation of Dr. L. C. Chapman Rawlins, studies similar to the above were carried out during the current year. Basic dyes, instead of acid dyes, were used. The data indicate that the basic dyes employed also combine with proteins in stoichiometric proportions when due consideration is given to the reaction of the protein solutions. In certain instances a satisfactory correlation between the amount of dye taken up by the proteins and the amino acids content was obtained.

"Certain phases of the problem relating to absorption of dyes by protein particles are at present being studied."

[An article by Dr. Schmidt and Dr. Rawlins covering the above results and entitled, "Studies on the Combination between Certain Basic Dyes and Proteins" has been accepted for publication in the *Journal of Biological Chemistry*.—Ed.]

EDWARD MACK, JR., UNIVERSITY OF OHIO:

[Work with the vacuum pump purchased with a Sigma Xi grant has been temporarily interrupted by Dr. Mack's absence from the country. He has been at work in Germany on a Guggenheim Fellowship. He returns in October and will submit his report during the current academic year.—Ed.]

REPORT OF COMMITTEE ON SIGMA XI GRANTS FOR 1929-30

The committee makes the following awards for the Academic Year 1929-30:

Dr. Robert Grant Aitken, Associate Director, Lick Observatory, Mt. Hamilton, California, $500, to aid in the preparation of a general catalogue of double stars with computations. The catalogue is to be printed by the Carnegie Institution of Washington.

Professor Arthur A. Bless, University of Florida, Gainesville, Fla., $250, for purchase of apparatus for study of the phenomena of dielectric absorption in relation to the theory of Debye.

Professors H. Clark, J. Murray Luck and C. V. Taylor, Stanford University, California, $1000, for investigating the selectivity of differentiated structures of living cells to X-rays of known intensity and frequency.

Professor William Harder Cole, Rutgers University, New Brunswick, N. J., $200, to purchase apparatus for study of effects of various gases—carbon monoxide, carbon dioxide, oxygen, nitrogen, etc.—on the respiratory activities of animals.

Professors Wheeler P. Davey and W. R. Ham, Pennsylvania State College, $1000, for investigating the conductivity of insulators under electron bombardment.

Professor Thomas H. Gronwall and Victor K. LaMer, Columbia University, New York, $500, part stipend of an assistant for numerical computation of tables to compare the Gronwall-LaMer theoretical formulas with experimental data on the Debye and Hückel theory of the solutions of strong electrolytes.

Miss Joyce Hedrick, Miami University, Oxford, Ohio, $300, for continuation of work on Dr. Fink's "Lichen Flora of the United States." This grant is a renewal of grants previously awarded and is supplemented by similar amount from Miami University.

Miss Dorothea Egleston Smith, Bryn Mawr College, Pennsylvania, $200, for work on a micro-titration method for the determination of free fatty acids in cells, with especial reference to work done on cytoplasmic inclosions.

WILLIS R. WHITNEY, *Director of Research, General Electric Company*
E. L. THORNDIKE, *Columbia University*
JOHN R. NORTHRUP, *Rockefeller Institute for Medical Research*
ARTHUR M. GREENE, *Princeton University*

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Washington University	P. A. Shaffer	A. S. Langsdorf	H. Lee Ward	L. F. Thomas
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Membership Certificates, stamped with the great seal of the Society. In packages of fifty prepaid, on advance payment of $2.50 for each package. Please specify carefully whether for active or associate members.

Index Cards, for members and associates. *Gratis.*

Chapter secretaries are requested to fill out these cards carefully giving PERMANENT addresses of the members, and return to the national secretary.

A few copies of the Quarter Century Record are available at $2.50 each.

Copies of the Constitution are available at 7 cents each.

SIGMA XI BANNERS

Chapters may obtain Sigma Xi Banners at the following prices:

Size 3 x 5	$ 8.00
4 x 6	12.00
5 x 8	20.00

CHANGES OF ADDRESS

All changes of address and all other correspondence should be addressed to the secretary of Sigma Xi, Edward Ellery, Union College, Schenectady, N. Y.